Human Health Collaboration Opportunities

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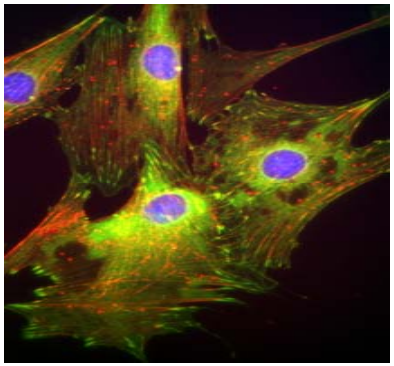


Two-photon microscopy images of cells

Laser-light scattering cataract detection

Exercise countermeasures

Microvascular analysis

Portable unit for metabolic analysis

Particulate image velocimetry in stent model

Version and Audit Information

Version : GRCBio-EnginneringCompetencies (9-5-07)

Disclaimer:
These charts continue to be updated and redesigned. We recommend that you check with Lynn Boukalik, (216 433-9701) (lynn.h.boukalik@nasa.gov) to ensure that you have the latest version. We are also maintaining an audit list of where this file is distributed, please tell us if you have distributed the file to others.

Ground breaking for the NACA Aircraft Engine Research Laboratory January 23, 1941

Glenn Research Center's Two Campuses

Cleveland (Brook Park and Fairview Park)

- **350 acres**
- **~1600 civil servants and 1200 contractors**

Plum Brook (Sandusky)

- **6400 acres**
- **~10 civil servants and 80 contractors**

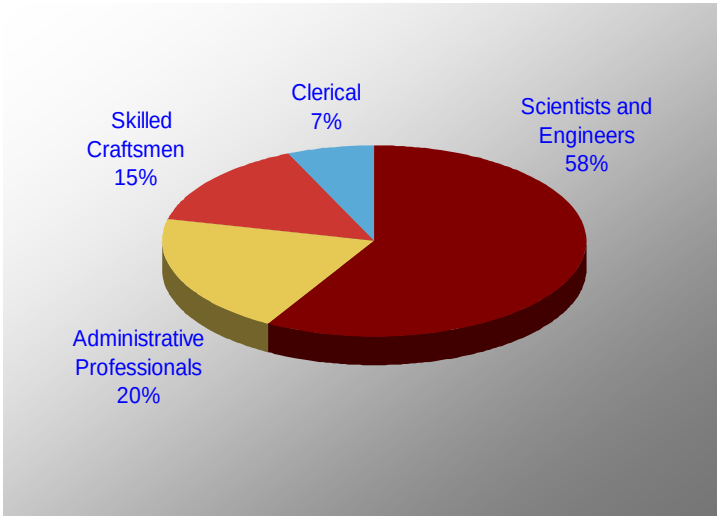
Civil Service Workforce

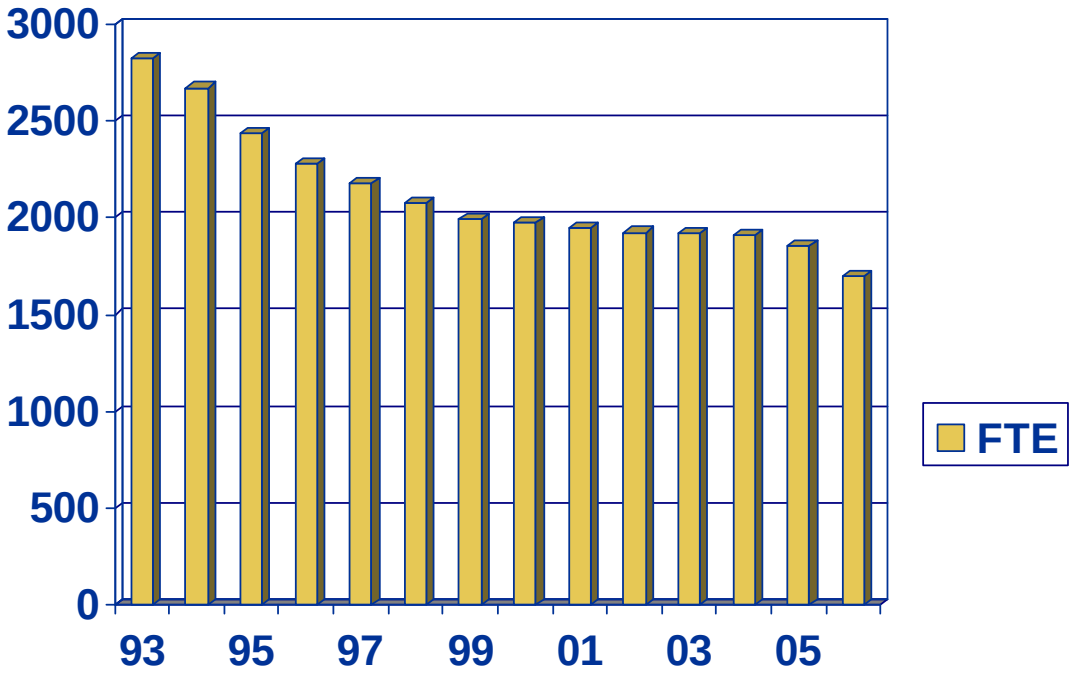
- 75% of workforce charges their time directly to the technical mission
- 67% of scientists and engineers have advanced degrees, 25% with earned Ph.D's

Administrative and Clerical

Scientists and Engineers

Skilled Craftsman





Mission and Product Lines

- Glenn Research Center is a NASA Field Center with the top priority to support the Agency's four **missions**:
  - Space Exploration
  - Space Operations
  - Earth and Space Science
  - Aeronautics
- GRC's major **product lines** of power, propulsion, and communications are critical to achieving the Agency's future objectives.

Competencies and Partnerships

- The **competencies** required to produce technologies for these major product lines are well aligned with priority national objectives.
- GRC will aggressively look to form **partnerships and seek new business opportunities** that fit the following criteria:
  - GRC competencies are required and the proposed effort will either maintain or strengthen those competencies.
  - The business case is positive for both our partner and GRC.

Interdisciplinary Human Health Collaboration Opportunities

Bio-engineering Research and Development

Competencies

- Biotechnology*
- Communications
- Electrochemistry*
- Fluids, CFD*
- Instrumentation, Controls, Electronics
- Materials*
- Mechanical Components

Environment

- Common issues
  - Gravity effects
    - Muscle
    - Cardio
    - Bone
  - Radiation exposure
  - Pilot / Astronaut monitoring
  - Breathing environment
  - Exercise countermeasures
  - Dust
- Habitat
  - Space suits
  - Vehicles-aircraft/spacecraft
  - Surface structures
  - Surface rovers

Functions

- Health maintenance
  - Examination
  - Diagnostics
  - Exercise
  - Water purity
  - Food
  - Psychological
  - Sleep
  - Human factors
- Repair techniques
  - In-situ processing
  - In-situ medicine preparation
  - Filter materials (fluids)
  - Wound healing

Technologies

- Communications
- Telemedicine
- Sensors
- Health assessment tools

Cross Cutting Competencies

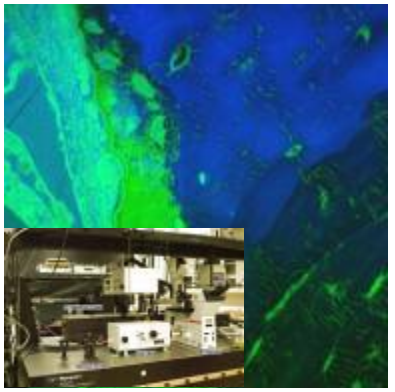
- Modeling, Simulation & Visualization*
- Nanotechnology*
- Program / Project Management
- Systems Analysis*
- Systems Engineering*

* Gravity Influenced

Selected Bio-Engineering Labs and Facilities

Vision diagnostic Lab

Exercise countermeasures



Two-photon fluorescence microscopy

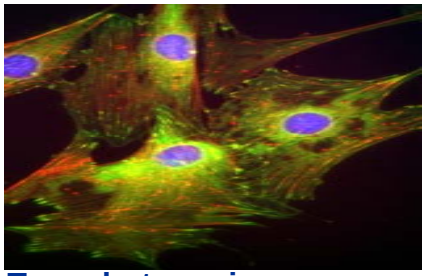
Microvascularization and Cell Culture Lab

Clean Room

Bio-Engineering

Description

- Research and technology development to support human exploration of space
- Interdisciplinary research to develop revolutionary technologies needed for aeronautics missions



Two-photon microscopy images of cells

Focus Areas

- Advanced biomedical diagnostics and instrumentation
- Modeling the effects of the space exploration environment on physiological components and systems.
- Biomedical sensors for space application
- Countermeasure systems to preserve human health during space exploration
- Advanced Fluid Systems for crew health care
- Computational simulations quantifying risk to crew health and mission

Prototype of head mounted eye disease monitoring systems

Exercise countermeasures

Facilities/Labs

- Bio-photonics lab
- Vision lab
- Cell culture lab
- Zero-Gravity Analog Exercise Countermeasures Lab
- Physiological Systems Computational Cluster
- Ultrasound and Advanced Diagnostics Lab
- Drop towers: access to sounding rockets, KC-135 and space station

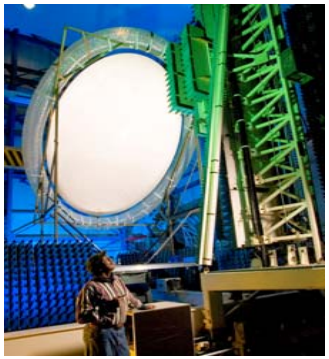
Accomplishments

- Development of eye disease monitoring system (2005)
- Improved understanding of bone loss and cardiac response in weightless environment (2006)
- Development of advanced fluorescence microscopy techniques to study cell physiology (2005/6)
- Virtual reality treadmill developed with Cleveland Clinic to maintain neurovestibular equilibrium in astronauts(2004)
- Portable Unit for Metabolic Analysis (PUMA) demonstration during NASA's undersea mission (2007)
- Constructed aero-gravity analog treadmill with vibration isolation and stabilization as a platform to quantify reduced gravity exercise and task efficacy (2006–present)
- 1st quantitative probabilistic risk assessment of bone fracture risk during exploration missions (2007)

Communications

Description

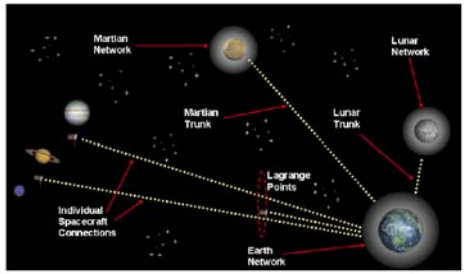
- Increased capacity communication systems maximizing information throughput, performance and portability for space, surface, mobile and aeronautical applications
- Development of communications systems and networks based on technologies that include radio frequency components and devices, digital and wireless communications systems, ground systems and communications networking techniques.



Near field antenna facility

Facilities/Labs

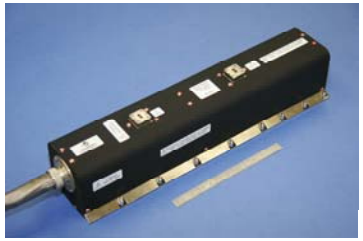
- Antenna ranges including near- and far-field antenna ranges, compact range, cylindrical near field range
- Radio frequency propagation laboratories
- Electronic component fabrication and characterization laboratories
- Network emulation laboratory
- Digital systems laboratory
- Space telecommunications radio system lab



Architecture

Focus Areas

- Large-aperture and miniaturized antennas.
- Ka-band atmospheric calibration studies
- Software defined radios
- Low power, reconfigurable transceivers
- Signal processing and networking devices
- Radio frequency amplifiers and devices
- Communications networks based on Internet Protocols
- Providing the highest integrity, end-to-end system solutions.



High efficiency 200 watt traveling wave tube

Accomplishments

- Demonstrated large (4m x 6m) class aperture deployable antennas (2005)
- Antenna element trade-off for Tracking and Data Relay Satellite System multiple access antenna (2006)
- Software defined radio architecture framework for space-based radios (2006),
- Space network router (2005)
- High Efficiency 200 W Traveling Wave Tube Amplifier
- High speed, Spacewire® networking interface controller (2006)
- Inter-spacecraft communications and ranging system (2005)
- Demonstrated the effective use of Ka Band for Space Communications (1995)

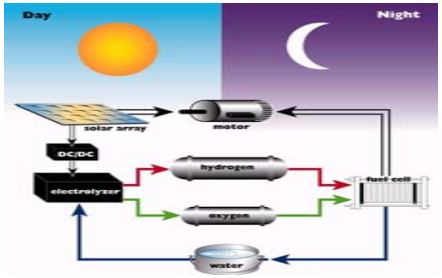
Electrochemistry-Physics

Description

- Fuel cells provide a primary source of power by converting hydrogen and oxygen to water and electricity
- Regenerative fuel cells combine a fuel cell with an electrolyzer capable of converting water back into hydrogen and oxygen (functions like a battery)
- Batteries - versatile, reliable, safe, modular, lightweight, portable energy sources
  - Lithium based batteries offer lower weight, smaller volume, and low temperature operations capability.

Facilities/Labs

- Fuel cell test facilities for performance, life testing of cell stacks/ systems (up to 25 kilowatts)
- Regenerative fuel cell test facility
- Dry room (1% relative humidity) for handling moisture sensitive materials used in lithium batteries
- State-of-the-art battery cycling facilities with >100 independent test channels
- Environmental chambers to evaluate performance as a function of temperature (-75 °C to +200 °C)



Regenerative Cell

Spirit/Opportunity Rover

Focus Areas

- Battery and fuel cell materials development
- Component design, development and characterization
- Electrochemical characterization of single cells and stacks
- Battery charge control methodologies
- System modeling and analysis
- Technology validation, mission operations

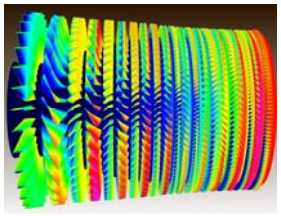
Accomplishments

- Gemini, Apollo, and Shuttle fuel cell technology Development 1960's - 1970's)
- Fuel cell demonstration scientific balloons; Helios (2001)
- Program with DoD for lithium-ion batteries for Mars Exploration Rover (2002)
- Evaluated battery technologies for Space Station and Electric Auxiliary Power Unit replacement for Shuttle (2000)
- Batteries for flight program – Space Station power system management, support day to day operations (1999 - present)
- Developed lightweight nickel electrodes, demonstrated the feasibility of bipolar nickel hydrogen battery designs (1984)
- Conducted Lithium-Ion verification test program (2001)

Fluids, CFD

Description

- Perform experimental and computational fluid dynamic (CFD) research for design and development of inlet and exhaust systems
- Research data from test facilities and computational codes for design tools and methodologies to advance the understanding of inlet and nozzle related flow physics, operability efficiency and turbine cooling capabilities
- Explore the fundamental principles of physics and chemistry through research in the unique natural laboratory of space

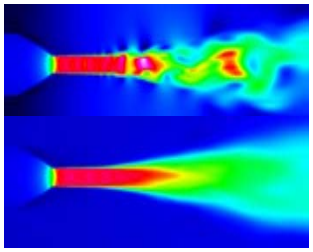


RANS and LES simulation of compressors

Thrust vector control

Instantaneous

Time-Averaged



Large eddy simulation of mach 1.4

Focus Areas

- Multiphase flows and phase changes
- Model development (vortex generators, bleed, turbulence, inlet/fan integration)
- Code development (Wind, APNASA, GLENN-HT)
- Multistage compressor and turbine CFD code development
- Conjugate heat transfer turbine CFD code development
- Large Eddy Simulation method development for fan, compressor and pump analysis
- Development of Reynolds Averaged Navier-Stokes code (RANS)

THE NATIONAL CENTER FOR MICROGRAVITY RESEARCH
NCMR
FLUIDS AND COMBUSTION

Facilities/Labs/Tools

- Supersonic wind tunnels (10'x10', 8'x6', 1'x1')
- Low speed wind tunnel (9'x15')
- Static nozzle test facility
- 15cm x 15cm SWT- fundamental flow physics
- Diffuser test rig- evaluation of subsonic diffusers
- Low speed compressor test facility
- Single spool turbine test facility
- Multistage and single stage test facilities
- Turbine film cooled vane facility
- Transonic turbine blade cascade
- Vibration and Statics Load Lab
- Mechanical design using Pro/Engineer
- Mechanical analysis (NASTRAN, ANSYS, ADAMS)
- Drop towers, sounding rockets and space station

Accomplishments

- Mach 2.4 external compression inlet concept developed (2005)
- Offset stream nozzle technology validated with CFD tools, utilizing state-of-the-art turbulence models for jet flows, and experimental database (2006)
- Aerodynamic testing of a highly loaded multi-stage axial compressor with 4.5 pressure ratio (2006)
- Developed Large Eddy Simulation technique for turbomachinery flow analysis. (2005)
- Tip gap aerodynamic and heat transfer measurements in transonic turbine cascade (2004)
- Completed performance tests of wave rotor (2006)
- Developed lunar rover test bed (2006)

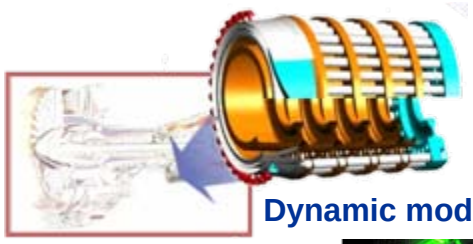
Instrumentation, Controls and Electronics

Description

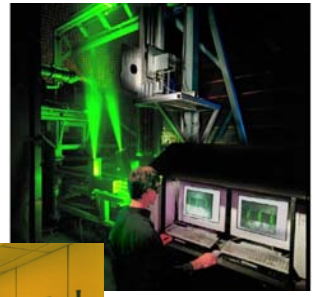
- Sensor development for harsh environments
- Optical instrumentation and NDE
- Controls and dynamics
- Design, development and testing for space flight instrumentation
- Digital circuit board design and analysis for aerospace
- Electronics for cryogenic environment
- Intercalated graphite conductors and radiation shielding

Focus Areas

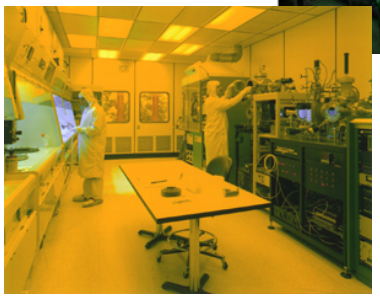
- Intelligent control and propulsion health monitoring and physics-based modeling
- Optical flow path measurements
- NDE methods development
- Silicon Carbide based electronic devices and MicroElectroMechanical Systems (MEMS)
- Robotics technology development
- Crew Exploration Vehicle avionics
- Crew Launch Vehicle data flight instrumentation and control system development/analysis
- Biomedical sensors for space applications



Dynamic modeling



Particle imaging velocimetry for jet noise characterization



Microsystems facilities

Portable unit for metabolic analysis

Facilities/Labs

- Dynamic modeling
- Propulsion health monitoring
- Particle imaging velocimetry
- Flight electronics lab
- Micro computed tomography
- Microsystems fabrication clean rooms
- Silicon Carbide chemical vapor deposition
- Harsh environment micro/nano-device laboratories
- Cryogenic testing chambers (5) to near absolute zero
- Environmental testing facilities (vacuum, temperature, humidity control)

Accomplishments

- 1400 ºC temperature sensitive paint sensor
- Zero false alarm fire detection system demonstrated (R&D 100 Award) (2005)
- High temperature (600°C) Silicon Carbide pressure transducer demonstrated (2006)
- Portable unit for metabolic analysis demonstration (2006)

Materials

Description

- Advanced lightweight structural concepts and designs for aerospace applications
- Micromechanics and life prediction of aerospace components

High temperature shape memory alloy (0.06 inch diameter wire)

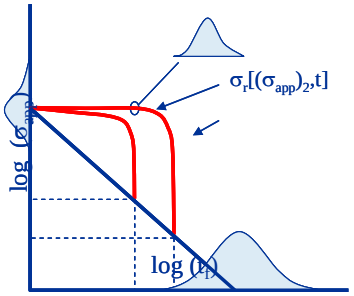
Ceramic matrix composite vane with environmental barrier coating

Facilities/Labs

- Facilities for processing, joining, and characterizing advanced polymeric, metallic, ceramic, composite materials and coatings
- Full range materials analytical facilities, including optical, electron, and atomic force microscopy, x-ray diffraction, spectroscopy and chemical analysis
- Over 100 world-class thermomechanical and subcomponent test facilities encompassing a wide range of temperature, environmental, and load regimes
- Atmospheric and high pressure burner rigs

Focus Areas

- Aerospace propulsion materials (metals, polymers, ceramics, coatings, composities) offering higher temperature capability and reduced weight
- Failure mode determination, damage mechanics, and life prediction methodology
- Multifunctional materials and structures
- Adaptive materials and structures
- Computational materials
- Nanotechnology materials



Probabilistic life prediction model

Accomplishments

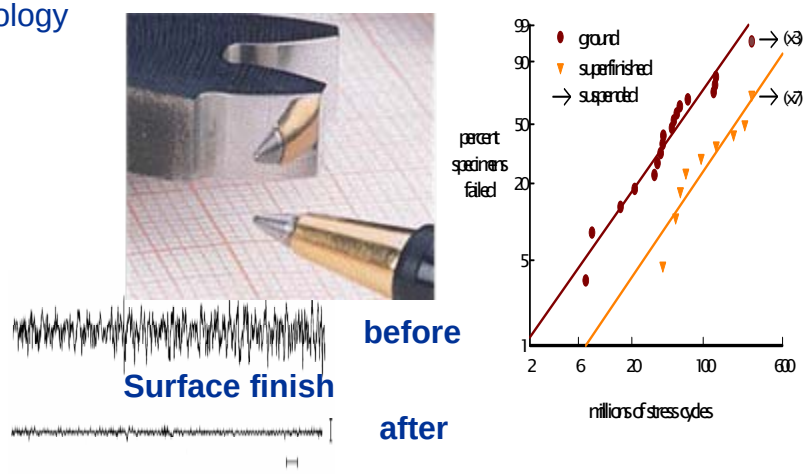
- Shape memory alloy with 300 ºC temperature capability (2006)
- Coated ceramic composite system for turbine vane (2005)
- Low density single crystal nickel-base superalloy (2006)
- Polymer cross linked aerogel (2006)
- Polymer nanocomposite (2006)
- Repair of reinforced carbon/carbon composite Space Shuttle tiles (2005)
- Integrated multiscale Micromechanics Analysis Code (2005)
- Advanced probabilistic structural analysis tool (2005)

Mechanical Components and Lubrication

Description

- Drive system technology
- Gears and bearings
- Fundamentals of lubrication (tribology)

Gear surface fatigue life increased by 4 X by superfinishing process



Facilities/Labs

- Contact fatigue rigs for spur gears (6)
- Fatigue rigs for spiral bevel / face gears (2)
- Spur gear bending fatigue test fixtures (3)
- Hybrid and fluid film bearing test facilities
- High speed helical gear train test facility
- 500 hp helicopter main rotor transmission test facility
- Gear noise / vibration test facility
- Space mechanisms tribology and component facilities

Focus Areas

- Component fatigue testing enabling development of advanced materials, processing and coatings for gears and bearings
- Advanced lubrication technology enabling high speed gear systems (rotary wing)
- Long life lubricants for space mission applications
- System testing of advanced components
- Analytical tool development for condition-based maintenance of mechanical components

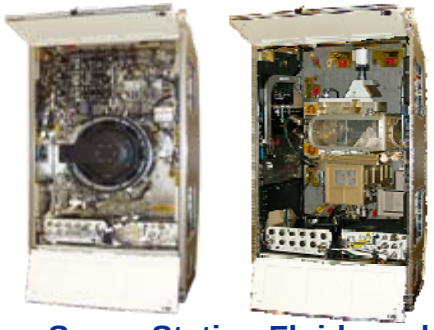
Accomplishments

- High speed gearing windage and performance assessment (2006)
- Advanced gear material contact and bending fatigue testing completed (2006)
- Advanced lubricant developed for extended loss-of-lube operation of gears (2005)
- Superfinished gear surface fatigue life testing completed (2004)
- Diagnostic tool developed for gear contact fatigue use data fusion and fuzzy logic (2003)
- Gear crack propagation methodology developed for thin rimmed gears

Systems Engineering

Description

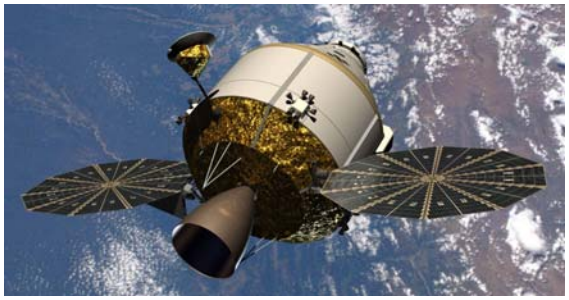
- Development and maintenance of systems engineering processes
- Application of systems engineering processes at a system level
- Technical management of systems



Space Station Fluids and Combustion Facility

Facilities/Labs/Tools

- Commercial software codes:
  - DOORS®
  - Cradle®



Crew Exploration Vehicle

Crew Exploration Vehicle

Crew Launch Vehicle

Delta-III Vehicle in B-2 facility

Focus Areas

- System development
- Requirements development and management
- Verification and validation planning
- System integration
- Technical decision analysis
- Technical reviews

Accomplishments

- Successful development, integration and operations of microgravity experiments on shuttle and station (1992-present)
- Leading the development of requirements for the Crew Exploration Vehicle (2005-present)
- Leading the systems engineering on various portions of the Crew Exploration Vehicle and Crew Launch Vehicle (2005-present)
- Accelerated training program for new systems engineers (2006)

Bio-Science Research and Development

Competencies

- Biotechnology*
- Communications
- Electrochemistry*
- Fluids, CFD*
- Instrumentation, Controls, Electronics
- Materials*
- Mechanical Components

Environment

- Common issues
  - Gravity effects
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- Habitat
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  - Vehicles-aircraft/spacecraft
  - Surface structures
  - Surface rovers

Functions

- Health maintenance
  - Examination
  - Diagnostics
  - Exercise
  - Water purity
  - Food
  - Psychological
  - Sleep
  - Human factors
- Repair techniques
  - In-situ processing
  - In-situ medicine preparation
  - Filter materials (fluids)
  - Wound healing

Technologies

- Communications
- Telemedicine
- Sensors
- Health assessment tools

Cross Cutting Competencies

- Modeling, Simulation & Visualization*
- Nanotechnology*
- Program / Project Management
- Systems Analysis*
- Systems Engineering*

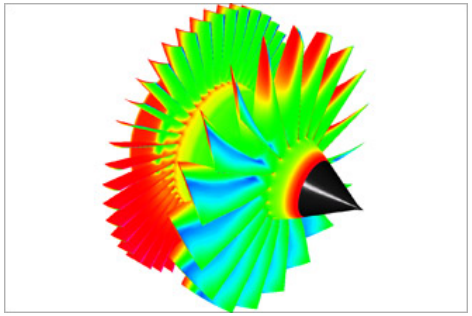
* Gravity Influenced

Modeling, Simulation, and Visualization

Description

- Design and analysis of component and system operations
- Support design of new technologies
- Provide detailed understanding of experimental data

3D iced inlet simulation



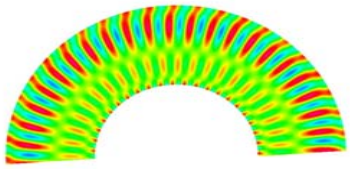
3D engine simulation

Facilities/Labs/Tools

- NASA Ames Columbia supercomputer
- Advanced computational concepts laboratory
- Glenn Reconfigurable User-interface and Virtual Reality Exploration Lab
- Large scale Linux clusters (~6)

Focus Areas

- Aircraft and rocket propulsion
- Ice accretion
- Noise prediction
- Virtual reality techniques
- Microgravity environments
- Cryogenic fluid management
- Fire safety in space habitats
- Spacecraft power systems
- Materials modeling/analysis
- Astronaut health/biotechnology
- Spacecraft mission analysis/design



Noise analysis

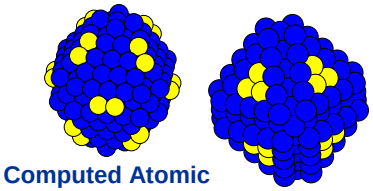
Accomplishments

- Numerical Propulsion System Simulator reduces analysis time by 55% (2001)
- TURBO-AE used by Air Force and 20 companies (1995 to present)
- Significant engine noise reduction achieved utilizing GRC codes (15 unique codes)
- System power analysis trade capability for the International Space Station (2003)
- Commercialized micromechanics analysis code with Generalized Method of Cells, Ceramics Analysis and Reliability of Structures and GENOA-Progressive Failure Analysis (1999)
- LEWICE 2D/3D (LEWis ICE accretion program) utilized by industry to design more efficient aircraft deicing systems for safe operations (2006)
- Virtual treadmill collaborations with Cleveland Clinic for astronaut health monitoring (2004)
- SIZER enables preliminary vehicle synthesis, sizing and scaling functionality for mission planners and requirements analysis

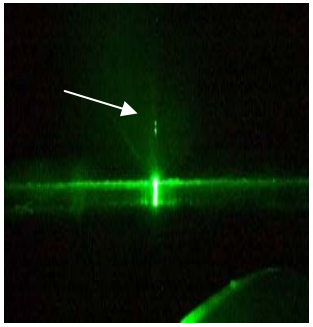
Nanotechnology

Description

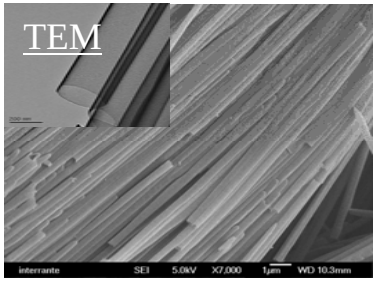
- Modeling - atomistic computational alloy design
- Nanomaterials - synthesis of Boron Nitride, Metal Oxide, Carbon-nanotubes and smart polymeric materials for high temperature and harsh environment use
- Nanophotonics - optical trapping for device manipulation and fabrication
  - quantum dots/optical sources for low power quantum communication and sensing in extreme environments
- Nanoelectonics - harsh environment sensors and electronics for nano-electro-mechanical systems (NEMS) devices dynamic energy systems



Computed Atomic Alloy Clusters



Optical levitation of microscale particles



Silicon Carbide nanotubes

Facilities/Labs

- Desktop atomistic alloy nanoparticle modeling
- High temperature synthesis/processing facilities
- Inert atmosphere gloveboxes, clean rooms
- Thin film deposition chambers
- Laser tweezers
- Quantum entanglement optics lab and world class quantum optics systems
- Harsh environment NEMS research facility for prototype design, fabrication and characterization

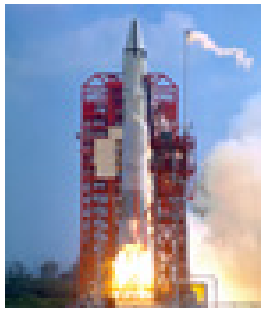
Focus Areas

- Free surface alloy energetics for designing novel alloys for solid-state hydrogen storage and low cost fuel cell catalysts
- Multifunctional high temperature materials for propulsion, sensors and communications
- Micro/nano device fabrication techniques for harsh environment and environmental hazard sensing and secure, ultra low power, high efficiency data transmission
- Design and fabrication of harsh environment NEMS materials and devices

Accomplishments

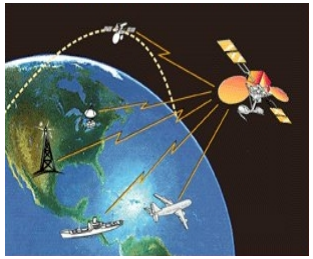
- Calculation of free surface energetics of nanoparticles (2004)
- Demonstrated Boron Nitride nanotube composite with superior hydrogen storage (2006)
- Detected Hydrogen with Tin Oxide electrospun nanofibers (2006)
- Experimentally verified a light propagation model for predicting light scattering from an optically trapped particle (2006)
- Quantum communication demonstrated over 75 meters at 10^{-18} Watt (2006)
- First demonstration of Silicon Carbide nanotubes with controlled wall thicknesses (2004)

Program/Project Management



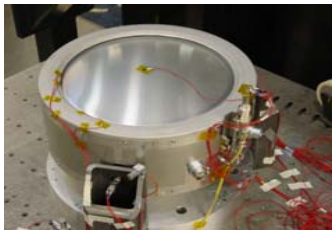
Centaur Launch Vehicles

- Managed 119 launches (1963-1997)
- Over 91% launch success rate



Communications

- Developed first ever Ka band communications satellite
- Over 150 organizations in 31 states
- Conducted over 100 experiments



Electric Propulsion

- Invented first Hall and ion thrusters; designed, built and delivered Deep Space I Ion Engine

Aeropropulsion

- Managed Energy Efficient Engine Program, demonstrated 15% reduction in fuel consumption, enabling development of GE 90 turbine engine

Space Station Freedom

- Designed the largest power system ever deployed in space

Microgravity

- Over 90% success rate in developing/managing 130 microgravity experiments on Spacelab, Spacehab, Mir and International Space Station

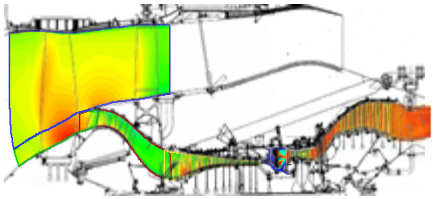
NASA Program/Project Management Training Levels

- 57 Level I Entry Level Project Managers
- 23 Level II Journey Project Managers
- 18 Level III Advanced Project Managers
- 6 Level IV Program Managers

Systems Analysis

Description

- Unique analysis abilities and tools
- Analysis of vehicle synthesis
- Mission analysis/design
- Propulsion and power analysis
- Concept development
- Aero safety analysis



Aeropropulsion

Lunar Lander

Facilities/Labs/Tools

- Numerical Propulsion System Simulator (NPSS)
- Structural Airfoil Blade Engineering Routine (SABER)
- Flight Optimization System (FLOPS)
- Orbital Trajectory by Implicit Simulation (OTIS)
- Space Power Analysis for Capacity Evaluation (SPACE)
- Process Based Economics Analysis Tool (PBEAT)
- Logic Evolved Decision (LED)

Focus Areas

- Architecture studies
- Space mission operations
- System trade studies
- Program support
  - Requirement definitions
  - Analytical analysis
  - Independent verification and validation
  - Metrics, earned valued
- Independent reviews
- Assess technologies
  - Gaps, benefits
- Methods development

Rocket propulsion

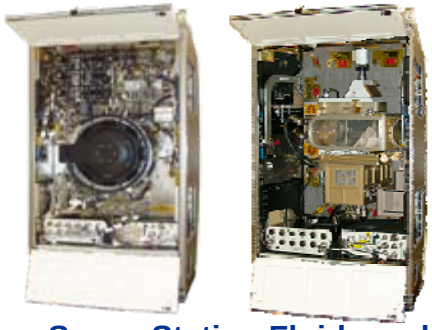
Accomplishments

- Green propellant thermal cycle evaluation (2006)
- International Space Station vacuum power design (2006)
- Flight Performance Systems Integration Group (2006)
- Analysis of Crew Exploration Vehicle/Crew Launch (2006)
- Vehicle power and trajectory (2006)
- Lunar Surface Access Module designs (2006)
- Lunar surface power architecture (2006)
- Cargo launch vehicle design (2006)
- Engineering based cost analysis (2006)
- Proposal development and evaluation (2006)
- Delta 3 oxygen/hydrogen upper stage historical repository of data (2006)

Systems Engineering

Description

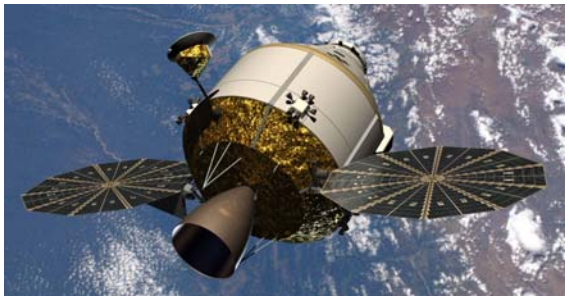
- Development and maintenance of systems engineering processes
- Application of systems engineering processes at a system level
- Technical management of systems



Space Station Fluids and Combustion Facility

Facilities/Labs/Tools

- Commercial software codes:
  - DOORS®
  - Cradle®



Crew Exploration Vehicle

Crew Exploration Vehicle

Crew Launch Vehicle

Delta-III Vehicle in B-2 facility

Focus Areas

- System development
- Requirements development and management
- Verification and validation planning
- System integration
- Technical decision analysis
- Technical reviews

Accomplishments

- Successful development, integration and operations of microgravity experiments on shuttle and station (1992-present)
- Leading the development of requirements for the Crew Exploration Vehicle (2005-present)
- Leading the systems engineering on various portions of the Crew Exploration Vehicle and Crew Launch Vehicle (2005-present)
- Accelerated training program for new systems engineers (2006)

Existing GRC Bio-Partnerships

- **John Glenn Biomedical Engineering Consortium**
  - Space Act Agreement with Case Western Reserve University (CWRU), Cleveland Clinic Foundation, University Hospitals of Cleveland, the National Center for Space Exploration Research to perform interdisciplinary research leveraging GRC expertise in fluid physics and sensor technology to mitigate critical risks to crew health, safety and performance.

- **Cleveland Clinic Center for Space Medicine**
  - Collaboration via a Space Act Agreement to provide an environment and mechanism to promote interdisciplinary research that will exploit the unique skills, capabilities, and facilities of both CCF and NASA GRC in support of long duration spaceflight
  - Congressional appropriation from FY06 funds for lecture series and grant seed money

- **BioEnterprise**
  - Space Act Agreement for collaborative efforts to further the development and commercialization of the life science related technologies in Northeast Ohio. Allows NASA access to BioEnterprise clients where technologies may be of benefit to NASA's mission.

- **NASA - NIH Interagency Agreement**
  - Technology transfer agreement for a NASA developed ocular diagnostic device to diagnose vision-related and systemic disorders both in support of NASA's exploration mission and terrestrial based medicine

- **CWRU/University Hospitals**
  - Congressional appropriation from FY06 funds applied to studying the effects of cosmic radiation

- **Wright Patterson Air Force Research Laboratory- Human Effectiveness Directorate**
  - Initiating collaborative efforts and identifying potential synergies in research goals and objectives from both NASA and WPAFRL programs. Leveraging off the consolidation of all aerospace medicine and human research activities at WPAFB in response to the BRAC directive.

Partnership Contact

- Many of our current competencies (people, facilities) are aligned with current national needs regarding Human Health / Bio-Engineering.

- We desire to partner, where appropriate, with organizations with organizations involved in Human Health / Bio-Engineering.

- To continue our partnership exploration, please contact:

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  Chief, New Business and Partnership Office
  Phone: (216) 977-7135
  Email: robert.j.shaw@nasa.gov

- Glenn Research Center Websites
  - **General information about Glenn**
    - http://www.nasa.gov/centers/glenn/
  - **Glenn Test Facilities Guide**
    - http://www.nasa.gov/centers/glenn/testfacilities/
  - **Glenn Research Center Resume**
    - http://www.nasa.gov/centers/glenn/about/index.html
  - **NASA Human Research Program**
    - http://microgravity.grc.nasa.gov/grcbio/